Robotic geometric characterization of subterranean voids: Constraining the influence of vent shape on volcanic eruption dynamics

Completed Technology Project (2015 - 2017)

Project Introduction

This proposal brings together experts in volcanic fluid dynamics (Mitchell), field volcanology (Parcheta), extreme robotics (Parness) and machine vision (Aydemir and Nash) to perform detailed mapping for the first time of the Mauna Ulu vent and conduit system, using a robotic platform and machine vision tools, in order to improve understanding of basaltic volcanic eruptions relevant on Earth, Mars, and other worlds. Magmatic fissures (linear cracks) are the most common geometry feeding volcanic eruptions. However, these conduits are poorly documented on Earth and other planets due to a lack of post-eruption preservation and the resolution limits of current geophysical techniques. Models and key interpretations about eruptions dynamics are sensitive to precise knowledge of conduit geometries. A well-preserved fissure exists on Kilauea volcano at the 1969-1974 Mauna Ulu eruption site, and this exposure provides a unique opportunity to directly measure a fissure system's original magmatic pathway geometry to tens, and potentially hundreds of meters into the subsurface. Human access is challenging or impossible, and typically not approved by the National Park Service, making robotic entry ideal (and for which we have a permit). Our goal is to survey in 3-D an exposed volcanic fissure on Kilauea volcano using a small, rotary, microspine robot to provide critical constraints applicable to a wide range of unsolved eruption problems. To accomplish this, we will utilize a previously designed rotary robot, VolcanoBot, which can descend into post-eruptive fissure conduits. To gain scientific data of eruptive processes and formation of solar system bodies, we will perform several field tests using VolcanoBots equipped with two different machine vision 3-D mapping sensors: Google Tango, and PrimeSense Carmine 1.09. The final reconstructed 3-D point cloud will inform fluid dynamical analysis of eruption dynamics, which provides a more accurate determination of eruptive processes and feedbacks in the shallow sub-surface. These dynamics, especially supersonic compressible flow, can be affected by decimeter scale vent structure and, consequently, understanding the geometry from a range of previously unobtainable base scales (centimeter to decameter) is particularly important. The Mauna Ulu field site is a superb analog to other planetary volcanic regions with similar features since eruptive volcanic fissures are common on Earth, Moon, Mars, Io and possibly Venus, Mercury and Enceladus. Volcanism represents a, if not the, dominant large-scale resurfacing mechanism on many of these worlds. Computationally reconstructing eruption dynamics from Mauna Ulu will increase our understanding of how typical volcanic conduit geometries form, evolve, and subsequently control eruption dynamics. We will provide public outreach and education opportunities to the local Hawaiian community during the field campaigns, as well as provide outreach seminars after the field sessions for communities on the mainland. This project is relevant to all three aims of PSTAR: science, science operations, and technology. The work is science-driven, with specific goals to answer questions about how volcanic eruptions work and evolve on Earth and other worlds. Documentation of the vents will

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Organizational Responsibility

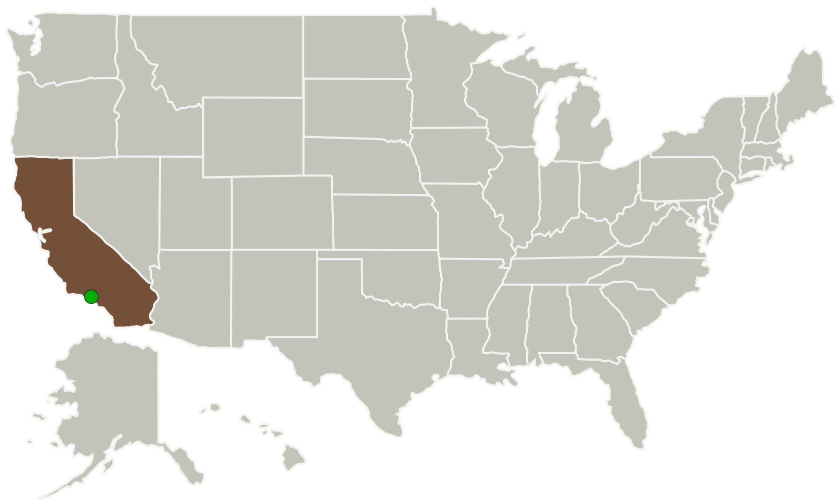
Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Planetary Science and Technology Through Analog Research provide unique data otherwise unobtainable that will be of broad interest. Exploration and documentation of vents will provide unique data otherwise unobtainable about how volcanic systems work. This project has fidelity in science operations because it directly tests the robotic and machine vision techniques (including communications, navigation, and traverses unique to science) in a compelling analog test area, allowing for validation of the methodology and enabling new concepts of operations in challenging or extreme environments. It also has technology fidelity, enhancing and implementing a unique robot and instrument payload to map the fissure system.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations
California

Project Management

Program Director:
Carolyn R Mercer

Program Manager:
Sarah K Noble

Principal Investigator:
Karl L Mitchell

Co-Investigator:
Karen R Piggee

Technology Areas

Primary:

- TX04 Robotic Systems
  - └ TX04.2 Mobility
    - └ TX04.2.4 Surface Mobility

Target Destination
Others Inside the Solar System